35 centavos a copy
₱4.00 a year
(10 numbers)

The Philippine Agriculturist

Foreign subscription
$2.50 a year
(U. S. currency)

Entered at the Post-Office at Los Baños, Laguna, as second-class mail-matter

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VOL. IX OCTOBER, 1920 No. 3

OPENING UP THE MINDANAO INTERIOR

As has been clearly visioned by two very able men, Governors Carpenter and Guingona, we also believe that Mindanao is a coming empire, and that the greatest wealth of the Philippines will be drawn from that vast country, one of the most prolific sources of strength to this Government and the Filipino people, and one of the most convincing evidences of real national greatness. I am not over-stating the case in the least since I now have not a little technical knowledge of the subject.

I believe most thoroughly that this matter merits the most active and enthusiastic interest and support of every official of this Government, and in earnest of this, Professor Gonzalez, myself, and others at the College have placed vacation and leave service at the entire disposal of Governors Guingona and Carpenter with the utmost enthusiasm, and the greatest resulting pleasure and satisfaction in serving under men whose whole lives and public service represent such effective and highly efficient constructive effort in so magnificent a cause.

It seems to me that just now, in the interest of really opening up Mindanao, our efforts should be concentrated on three things, securing the construction of the bridge at Maluco, and roads beyond Malaybalay, and inducing the Government to permit American capitalists to begin the immediate construction of the Cagayan-Davao narrow-gauge electric line.

As to further effective publicity for Mindanao, I have already expressed the belief to Governors Guingona and Carpenter that the greatest of all immediate needs is an extensive series of real photographs—views of all features of the vast interior, illustrating its unparalleled natural resources, its beauty, and its many

points of interest These photographs should be as good as those appearing in the *National Geographic Magazine* in which case we can easily get them—with appropriate text—into all the principal magazines of the world. We can then bring before the whole world in attention-arresting form some of the wonderful facts about Mindanao, as for instance, that Cotabato—only one of the seven great Mindanao provinces—is larger than the whole of Belgium; that the vast interior can produce more sugar than Cuba; more rice, corn, coconuts, abaca, and food products than all the rest of the Archipelago is producing to-day; as good tobacco as Isabela can produce; more coffee than is produced in Java; more cacao than on the Gold Coast; and enough rubber to supply the entire needs of the United States! And that in a country of such tremendous possibilities as this, with salubrious climate, high grade, first class agricultural lands are being offered at lower prices than such lands under such conditions can be obtained anywhere else in the world! We can quickly procure from America a technically trained photographer capable of splendidly efficient service in this work, and the Government should properly authorize this from available funds immediately. Personally, I do not believe that the services of the official photographers of the Bureaus of Science and Agriculture are so urgently needed on any present project as on this Mindanao work, in conjunction with our technical agricultural investigations now in progress. Every day of delay in the active development of interior Mindanao means the loss to this country of incomputable fortunes.

CHARLES F. BAKER
Dean, College of Agriculture.

He who sows the ground with care and diligence acquires a greater stock of religious merit than he could gain by the repetition of ten thousand prayers.—*Zoroaster.*

RANGE CATTLE MANAGEMENT IN THE PHILIPPINES[1]

By B. M. Gonzalez

Of the Department of Animal Husbandry

It is estimated that out of a total area of 120,000 square miles, there are 20,000 square miles of grass land in the Philippines, or 6,000 square miles more than the total estimated cultivated area of 14,000 square miles. A great deal of this grass land is on hillsides, more or less sloping, and in places inaccessible, but most of it is good rolling grass land in sparsely populated regions suitable for keeping cattle in large herds. Some of the land is in islands which are perfectly isolated, and where rinderpest is practically unknown.

Contrast with the above the fact that there are only 603,107 head of cattle in the Philippines[2] and that the annual importation of cattle, carabaos and meat products amounts on an average to about ₱3,502,983[3] for the five-year period 1915-1919.

The most extensive grass areas in the Islands still unoccupied are found in Mindanao, especially in the provinces of Bukidnon, Cotabato, and Davao. There are also less extensive stretches of land suitable for cattle raising in Luzon, in the provinces of Cagayan, Isabela, Mountain, Nueva Vizcaya, Rizal, Laguna, and Tayabas; and in the islands of Mindoro, Catanduanes, and Masbate, and in the Visayas in the island of Bohol, and in a number of the smaller islands.

Most of the grass areas are traversed by numerous rivers and creeks and the animals at any one place would not need to travel far for water. A few wide areas are not adequately watered, but these offer no immediate problem, as they will naturally be taken up much later, when it may be found advisable to put up artificial watering places as is done in a number of localities in the United States. In a few of the smaller islands of the south there have been developed what may be termed "salt water cattle". These islands are so small that they have no steady supply of fresh water and the cattle on them drink the salt water of the sea.

The predominant grass in the Philippines is cogon (*Imperata cylindrica* L.), a rank perennial which sometimes grows to a height of a meter and a half. Cogon is not to be despised as a range grass. As a matter of fact most of our wild grass lands are cogon areas. One of the advantages of cogon is that the pasture can be easily renovated or rejuvenated by burning. It is also a very fast grower. Its disadvantages are that its yield per unit area is comparatively low and it is watery when young and rather fibrous, rough, tough and unpalatable when old. Inasmuch as it takes a long time to exhaust the cogon root stock, even with rather close cropping, there is a gradual change from cogon to the finer grasses. Cogon itself assumes a short stocky growth under such conditions. Well managed cogon areas have been easily improved and their carrying capacity doubled or trebled in the course of a few years by such transformation. Talahib (*Sacharum spontaneum* L.), a grass next in importance, has smaller leaves and is more fibrous than cogon, and has a woody stalk. It is a very poor range grass and animals eat

[1] Experiment Station contribution No. 38.
[2] Philippine Bureau of Commerce and Industry, Statistical Bulletin 2, p. 81, 1919.
[3] Annual Report of the Insular Collector of Customs for 1919, 48-49, Manila, 1920.

only its young leaves and the tips of the older leaves. Under close grazing, these grasses are replaced by finer and more succulent grasses, principally carabao grass of the genus *Paspalum*, also by paraguis (*Eleusine indica* L. Gaertn), banig usa (*Panicum flavidum* Retz.) cawad-cawad, bermuda grass (*Cynodon dactylon* (L.) Pers) and similar grasses. With the advent of the finer grasses, bushes, and shrubs of little or no value as pasture crops come in, and these must be removed occasionally to improve the pastures.

There are apparently few poisonous range plants in the Philippines, and those that may be present do not do any harm, as there is usually plenty of pasturage the year round. No stock poisoning has ever come to my notice. It may be that the stock know how to avoid the poisonous plants.

MANAGEMENT OF THE RANGE

It is commonly accepted in the Philippines, based on the experience of the Bureau of Agriculture at the La Carlota Stock Farm, that one hectare will support an ox the whole year round in the Islands. While this area may be enough for an approximate average, it is prudent to recognize that the carrying capacity of Philippine ranges varies considerably, according to the vegetation and the rainfall in a locality. I have seen places where more than three hectares were needed to maintain a head, and, again, other places where more than three head could live the year round on one hectare of pasture. On closely managed areas we have carried as many as five on one hectare. This latter, of course, is extreme. In any case, in estimating the capacity on one's pastures, one should err on the liberal side if he wishes to produce good animals. It must also be borne in mind that there is a constant increase in the herd and one should not figure on putting on the full quota of animals his pastures are able to carry. A good plan is to allow at least double the number of hectares estimated for one animal for every breeding cow in the herd. To increase the carrying capacity of one's range the animals should be confined in a comparatively small area at any one time, and as the grass becomes exhausted moved on to another.

Whenever animals are given the run of a wide area, the animals will select their food. Young grass is relished by animals, and whenever they can get it, they neglect the older grass which then gets rank and tough so that after a while it has very little food value and the animals will not even touch it. As the animals always seek for the tender growth, after a time the rootstock is exhausted and the grass finally dies.

When the pastures are not properly rotated one may see an abundance of these bunches of rank grass which are worse than useless as they have to be burned or cut by hand before any new growth can come up. If the animals are confined to a limited area, they will crop all the vegetation on it and when this is done, they should be removed to another area and not turned into the first one again until a good growth is on it.

Close cropping is advantageous as this kills most of the cogon and promotes the growth of finer grasses of lower and more luxuriant verdure.

IMPROVING THE RANGE

Some people believe that rain is about the only factor for the production of grass on the range; that when there is rain, there is plenty of feed, and when there is no rain there is no feed. To a certain extent this is true for rain promotes the

growth of the vegetation and during rainy weather one need not fear for lack of grass. But how much can rain accomplish when most of the grass has already been killed during the dry season and substituted by rank weeds and brush? It will only promote the growth of the latter and thus decrease the usefulness of the range. The problem, therefore, is to control grazing so as not to kill the grass in order that it may grow and recuperate when the rainy weather comes.

A proper rotation of pastures will increase the carrying capacity of the range. This may be accomplished in several ways. The animals should not be turned on a pasture while the grass is very young. This is neither good for the catttle nor for the range. Young grass is very watery and laxative and may induce the animals to scour. Inasmuch as there is very little food value in it, the animals will have to eat very much more in order to get a full feed. At this stage the growth is so scant that the animals will have to exhaust a very wide area before they become satisfied. One may imagine for example how many meals an ox will make of a hectare of three-months old corn.

Overgrazing is most likely to occur close to the headquarters, especially if a corral is kept, and close to the watering places. To avoid killing out the grass close to the watering place, one should not water his animals in the same place all the time. When a creek or creeks run through the range, it is comparatively easy to provide a number of watering places along the creek.

CORRAL AND FENCES

A covered corral is not absolutely necessary for range cattle in the Philippines. The weather rarely gets cold enough to affect the animals seriously. The corral has its advantages and disadvantages.

There are many objections to corraling animals every night, as is the usual practice on many cattle ranches. First, the manure accumulates at the corral and has to be removed by hand, thrown in a pile, dried, and burned, and thus wasted. It is rarely possible on a cattle ranch, with its limited supply of labor, to cart it away to the fields. At best the corral is insanitary, as there is continuous evaporation of the urine, and the floor is most always moist if not actually wet. Where cattle are kept in large numbers, labor is usually very scarce and can be used to better advantage than shovelling manure. There are not many nights in the year in the Philippines when animals are really better under shelter than outside. If the animals sleep outside, there is no bother with the manure, and it is scattered in the pastures right where it is most needed.

A better plan than the corral is to provide a shelter under which the animals can go when they wish to. In the College our plan is to put a shelter between two pastures used in rotation. An enclosure is put around it with two doors, one leading into each lot, and one of the doors is open all the time. The animals are taught to go into the shelter by driving them in, allowing them to sleep there and salting them a few times in the enclosure, especially during bad weather. Once they know where the shelter is they go to it when they need to. Where trees are plentiful in the pasture, or where it is adjoining a forest, the shelter may be dispensed with altogether.

Fencing is advantageous as a general rule, for it makes possible the complete isolation of one's herd and a convenient division of the range into unit areas. But fencing is expensive. Therefore in locating a site one should choose as far as

possible a secluded area, delimited by such natural barriers as the sea, rivers, mountain ranges, and forests. Such locations are not difficult to find in hilly regions in the Philippines where most of the grazing country is. If a cattle-man is able to locate himself in such a place, he will need comparatively little fencing to completely isolate his herd, and while at the beginning he may have more land than animals, he can afford to neglect the proper handling of his pastures. As the herd increases, however, and the income starts to come in, he should surely invest in fences.

For the ranges, a three-strand barbed wire set on posts three meters apart will be found sufficient. Wood or bamboo set in the ground under our conditions deteriorates rather rapidly, and it may be found to be more economical in the long run to set a few concrete posts each year to replace the rotted posts. A more economical way yet is to set freshly cut posts of such easy growing trees as ipil-ipil (*Leucauena glauca*) and madre-cacao (*Gliricidia sepium* (Jacq.) Steud.) and allow them to grow, and in a few years one will have a veritable hedge row that will furnish shade, will serve as windbreak, and the leaves and pods will be relished by the stock.

For the purpose of inventory and for assembling the herd for inspection, there should be fenced an enclosure big enough to hold the whole herd without undue overcrowding. This should be strongly fenced, but not with barbed wire, as this may lead to injury as the animals crowd each other. Woven wire or boards nailed on strong stakes set close to each other so as to make it very strong will serve the purpose. A funnel shaped alleyway, narrowing down to a little more than the width of an ox should lead into other compartments. This narrow portion or "squeeze" should be very strong, and should be provided with gates. While the animal is in it, he may be branded standing, or ropes put on him preparatory to throwing him when he gets into the other compartments for castration, treatment in case of wounds, etc. The squeeze may lead into two or more compartments for the purpose of temporarily separating animals to be castrated, and separating those that belong to the different groups in a classification planned.

THE STOCK

To start the herd, one should select good cows from prolific mothers. Many times, however, in starting one has to content himself with what he can get. It should be the constant aim of the stockman to improve his herd all the time. This may be done by culling out the poorest and barren cows every year. Special effort should be made to secure good bulls as it is through them that the greatest improvement can be accomplished at the least cost. Whatever breed may be selected, the individuals should be vigorous and good specimens of the breed. There is a bad practice common in the Philippines, which cannot be condemned too strongly, and that is to allow buyers to pick out from the herd the best individuals, thus leaving nothing but poor bulls to propagate.

Indian cattle acclimate themselves easily in the Islands and have proven to be excellent grazers, surpassing even the natives in this respect. They are also resistant to ticks and rinderpest, characters which they impart to a certain degree to their offspring. Indian animals are not as good work animals as the native stock, and they are usually mean in disposition. As meat animals, they are more bony than the native cattle and their meat is tough, coarse, and dark colored. Grade offspring or "mestizos" are about intermediate in the above characters.

European animals are superior to the Indian as beef animals, but they have generally proven to be too delicate for our conditions, and moreover, they are rarely available in the Islands. Until more work has been done towards the acclimating of European breeds, it is not advisable for a common breeder to bother with them.

MANAGEMENT OF THE HERD

One should allow four bulls to every hundred cows, or one for every twenty-five. Where the topography of the land is fairly level and the range more or less restricted three bulls for every hundred may be found sufficient.

At least once every year an inventory of all animals should be taken in order to find out the rate of increase. Well managed herds will have an average increase of 75 to 90 per cent, while poorer herds will only have from 50 to 60 per cent.

Large herds may be conveniently divided into smaller units. The following division was suggested to Mr. Florentino Cruz, lately of the Crescent Star Cattle Co., of Bukidnon, Mindanao, and he reports favorable results from it:

1. Dry cows.
2. Cows nursing calves.
3. Steers and heifers below two years old (weanlings).
4. Select herd for improvement work.

Cows from Herd 1 should be transferred to Herd 2 upon calving. A bull should be allowed in this herd for every twenty-five to thirty cows. This arrangement will facilitate inventory taking as constant record is kept of increases, which is not possible in a mixed herd.

Cows from Herd 2 are to be transferred to Herd 1 after weaning their calves, which should be from six months on, depending on the development of the calf, and the calves should be placed in Herd 3. This herd should contain the tamest bulls and the best available for the main herd, and should be placed in choice pastures preferably close to the central station so as to be closely supervised.

From Herd 3 will come the work animals and beef animals to be sold. The heifers should be transferred to Herd 1 when about two years old. Herd 3 should contain no bulls, as the bull calves should be castrated before being placed in this herd.

Herd 4 will furnish the bulls for the rest of the herd. It should contain the choicest animals of the herd, preferably not more than fifty cows and the best bulls available. Undesirable bull calves should be castrated and put in Herd 3.

It is highly desirable that cattle herds be restricted to not more than one thousand cows, which together with the bulls and coming calves, will come up to around two thousand head. In this manner the animals will not have to go very far from headquarters to pasture and drink, and there is also less danger of overgrazing the pastures close to the center and thus absolutely depleting them. This arrangement will be found wiser when it is considered that infectious diseases may make their appearance any time and will work greater havoc in one big herd than in several small ones segregated from each other.

When the season is favorable, the animals may be branded and castrated. A favorable time for castration should be when the weather is cool, when the flies are few, and when the pastures are good. From December to February will be found to be a good period for most places in the Philippines.

Cattle require salt, and if they are not furnished it they grow restless. The first time salt is given, it should be restricted as otherwise the animals are likely to overeat and have digestive disturbances. They may be salted two or three times a week. Salting should be done by hand in order to accustom the animals to the presence of the caretaker so they will not fear his approach. The salt may be placed on the dry ground in a long line in places far from the watering place as this will induce the animals to utilize the grass in the less accessible places. Animals salted this way get acquainted with the herdsman, become tame and are easy to catch whenever it is necessary to do so. Sometimes animals are salted by placing the salt in boxes and the animals come to it as they want to. This method is not recommendable as the herdsman would be losing his best opportunity to come in close contact with his animals. The greater effort required in hand salting will be amply rewarded by the ease with which animals may be caught when wanted. With the aid of salt animals may also be led into the corral for the purpose of inventory, branding, castration, etc. One should provide one pound of salt per head per month or twelve pounds per year, approximately.

CASTRATION

Animals not wanted for breeding should be castrated. Undesirable animals being more scrubby and agile can usually breed ahead of the bigger, heavier, and better bulls, with the result that the poorer animals sire the next generation.

An animal castrated young, before being weaned, and before he is sexually developed, suffers little, usually recovers from operation very quickly, and with very little set back in his growth. Normally it is best to castrate calves when about two months old. In case it is desired to develop work animals, however, it is best to delay the operation until the animals are two years old or even older. Then the neck and shoulders become heavier.

Procedure.—After disinfecting the scrotum and the parts around, the operation may be performed by making a longitudinal incision on one of the halves of the scrotum parallel to the body, and cutting up the skin and membrane to the testis. The testis is then freed from the adherent membranes and these are then allowed to retract. The cord is pulled tight and severed by means of a crushing instrument called an emasculator. The operation is repeated with the other half. For disinfectant a solution of carbolic acid, cresol, or creoline may be used. The wound should be disinfected thoroughly, anointed afterwards with vaseline containing an antiseptic and tar as a fly repellent. Flies are about the worst enemies of open wounds in the Philippines. They deposit their eggs in the wound and very soon grubs are found which eat up the surrounding flesh. In case this happens, the animal should be thrown down, and the wound examined. In case grubs are found, chloroform may be poured on them to stupefy them and then they can be removed with a probe or pointed stick. The wound should then be disinfected thoroughly once more and precautions taken so that no more flies get into it by applying a goodly dose of tar on it.

AILMENTS

Outside of infectious diseases, the most common ailments that may be observed in range cattle are bruises and wounds caused by goring, barbed wire, and other sharp objects. These should be thoroughly disinfected and treated similar to the wound caused in castration.

Great care should be exercised in the introduction of new animals into the herd. Any new animal should be quarantined for about one month before putting it with the herd. During this period it will likely show any diseases it may have had dormant at time of its purchase. Many herds have had infectious diseases introduced into them that have caused the annihilation of a large percentage of the animals by not observing this simple rule.

An isolated pen should be provided to serve as hospital for any animals that may become sick.

A stockman should have a small medicine chest containing the following:

1 emasculator.
1 trocar and canula for bloat. This may also be used in ringing bulls.
1 hard rubber syringe for flushing wounds.
1 funnel with one meter rubber tubing for rectal injection or enema.
1 clinical thermometer.
1 knife for small surgical operations, castration, etc.
1 small pair of shears for trimming wounds and cutting bandages.

He should have a supply of the following articles, amount depending on the size of the herd:

Creoline, lysol, or carbolic acid for disinfectant.
Vaseline or cosmoline.
Tar, medicinal.
Absorbent cotton.
Bandage cloth.

There is a room for extending the medicine chest indefinitely, as necessity arises. The following may be added:

1 liter raw linseed oil.
5 Kg. Epsom salt, or magnesium sulphate.
500 gm. calomel for dusting wounds.
500 gm. tincture of iodine.

THE GROWTH OF RICE AS RELATED TO CONCENTRATIONS AND PROPORTIONS OF FERTILIZER SALTS ADDED TO SOIL CULTURES[1]

By Sam F. Trelease and Mariano C. Jurado

THREE TEXT FIGURES

The experiments reported in this paper deal with the growth of rice in water-saturated soil to which the three salts, primary calcium phosphate [$Ca(H_2P0_4)_2$], ammonium sulphate [$(NH_4)_2SO_4$], and potassium sulphate [K_2SO_4], were added in various proportions and in four total concentrations. A study at the College of Agriculture (1) has already shown that, using a method similar to that employed in the present study, the growth of rice is greatly improved when these three salts are added to soil cultures in the proper proportions and with a total osmotic value corresponding to approximately 0.5 atm. at 25°C. In the previous study 36 sets of proportions were employed; but only a single total concentration was used. The main purpose of the present work was to study the effect of the total concentration of the fertilizer mixture upon the growth of the rice plants. Four total concentrations were studied by means of four series of cultures conducted simultaneously. In the first concentration series the salt mixture added to the soil was calculated to have an initial total concentration of approximately 0.5 atm. at 25°C. in 19 liters of water; in the second concentation series the salt concentration corresponded to 1.0 atm., in the third to 2.0 atm., and in the fourth to 3.0 atm.

With each total concentration 10 different sets of salt proportions were tested. These 10 sets of salt proportions included all sets of proportions of the three salts when the unit of variation of each salt was equal to one sixth of the total osmotic value of the salt mixture. The cultures and salt proportions used in this work are represented by the triangular diagrams of Figure 1. Each of the four triangles in this figure represents one concentration series. Thus, T 0.5 shows the 10 cultures of the first series, in which each salt mixture has a value of 0.5 atm. The base of the triangle denotes cultures having one sixth of the total salt content due to $Ca(H_2PO_4)_2$, etc.; while the apex of the triangle represents a culture having four sixths due to $Ca(H_2PO_4)_2$. Similarly, the left-hand margin of the triangle represents cultures whose salt mixtures have one sixth of their total value due to $(NH_4)_2SO_4$, while the point at the extreme right of the triangle denotes a culture having four sixths due to this salt. In like manner, the right-hand margin of the triangle represents cultures having one sixth due to K_2SO_4, and the point at the extreme left represents a culture having four sixths due to this salt.

The three other diagrams in Figure 1 represent the cultures of the other concentration series. All of the cultures of T1 have a total concentration of 1 atm.; those of T2, of 2 atm.; and those of T3, of 3 atm. The four series differ only in total concentration; the relative proportions of the three salts are the same for TO.5, T1, T2, and T3.

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1 Thesis presented by Mariano C. Jurado for graduation from the College of Agriculture No. 116. Experiment Station contribution No. 40.

Table I shows the amounts and proportions of salts actually used in these experiments. The table gives the culture numbers; the amount of $Ca(H_2PO_4)_2$, in grams; the number of cubic centimeters of m/2 $(NH_4)_2SO_4$; and the number of cubic centimeters of m/2 K_2SO_4. The chemical calculations for this table were made in a manner similar to that described by Tottingham (2).

The experiments here described were carried out in the Department of Plant Physiology of the College of Agriculture, Los Baños, P. I., during the period from June 24 to December 26, 1919.

EXPERIMENTS AND RESULTS

Two sets of experiments, designated as Set 1 and Set 2, were conducted. They were similar in materials and methods, but were carried out at different times of the year.

Seeds of the *Sanglay Puti* variety of rice were soaked in water for fourteen hours and then planted in seed-boxes. On July 26, 1919, seeds for Set 1 were sown in seed boxes filled with sieved soil; on August 4, 1919, the operation was repeated for Set 2. Germination followed in about three days after sowing, and the seedlings made uniform and vigorous growth. Five-gallon petroleum cans that had been cleaned, and whose inner surfaces had been paraffined, were used as culture vessels.

The soil for both sets was a clay loam obtained from a field on the College Farm which had previously been planted with sweet potatoes. For Set 1, 20 kilograms of soil were thoroughly mixed and put in each can; for Set 2, 21 kilograms were used. The soil used in these experiments contained about 20 per cent of water. In preparing each culture the required amounts of $Ca(H_2PO_4)_2$, K_2SO_4 and $(NH_4)_2SO_4$ were mixed with the soil. The addition of $Ca(H_2PO_4)_2$ was made with the dry salt; the other salts were added by means of solutions in water. After adding the fertilizers the soil was saturated with water. The seedlings for Set 1 were transplanted on August 7, 1919; and those for Set 2, on September 13, 1919. Eight vigorous seedlings were planted in each culture and watered often enough to keep water standing to a depth of about 3 centimeters on the surface of the soil. In Set 1 four seedlings were removed from each culture on August 23, 1919, leaving the four most vigorous plants; on September 1, 1919, two plants were removed, leaving two plants in each culture. In Set 2 the same procedure was followed on October 10 and October 17, 1919, respectively.

In Set 2, measurements were made of the length and width of leaves, Three of the most vigorous leaves of a culm were measured. As five culms were selected from a plant, thirty leaves for two plants were measured in this way.

The cultures of Set 1 began to flower on September 24, 1919. Those of Set 2 began to flower on October 30, 1919. When seeds began to form, the panicles were bagged with cheese cloth to prevent their being attacked by birds.

Harvest for T0.5 and T1 of Set 1 occurred on November 8, 1919; for T2 and T3 on November 15, 1919. T2 and T3 were harvested one week later than the other cultures because some of the plants were still green at the time when T0.5 and T1 were harvested. Harvest for T0.5 and T1 of Set 2 occurred on December 19, 1919; for T2 and T3, one week later. In harvesting, each of the panicles (for the 2 plants in each culture) was first measured from the tip to the first node. The panicles were cut from the plants and put in paper bags to dry. The tops

were then harvested. The lengths of the bearing culms were measured, and the average length was obtained for each culture.

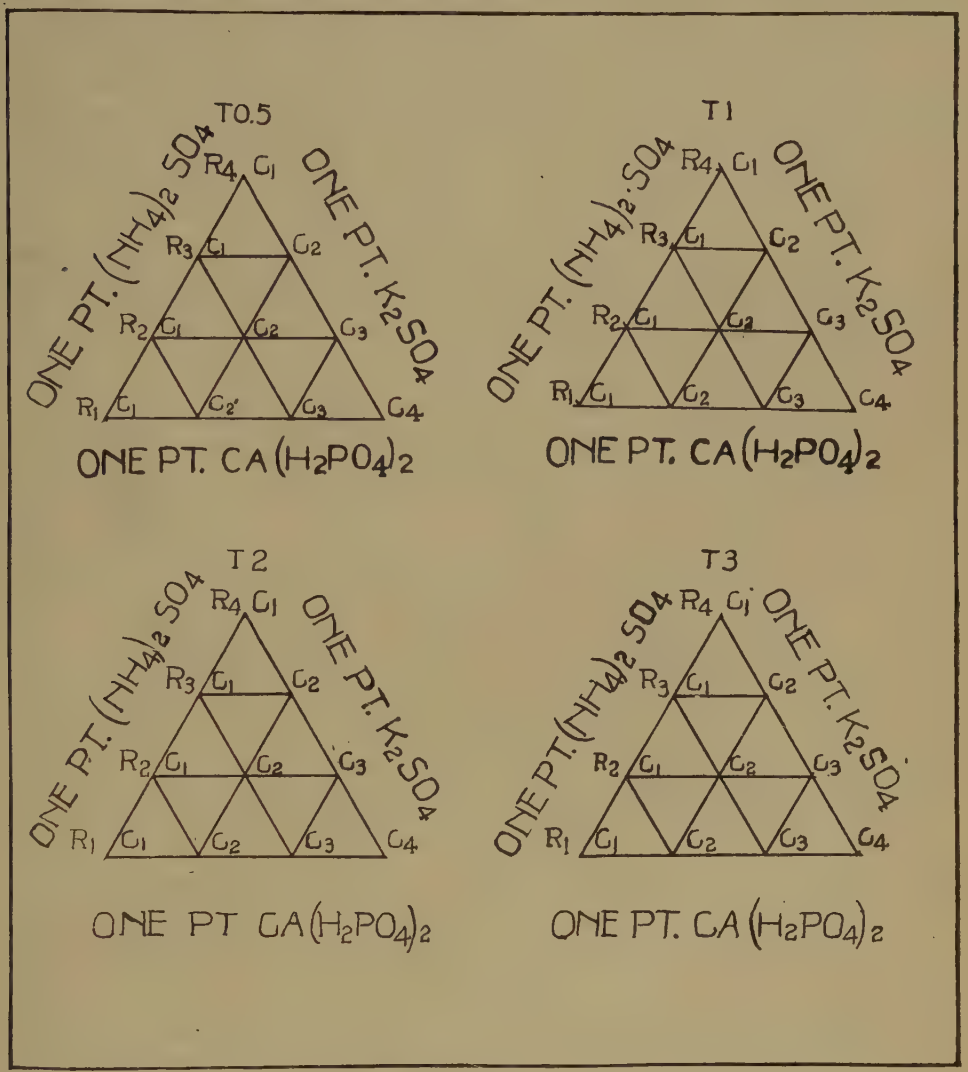

Fig. 1. Triangular diagrams showing culture numbers and salt proportions for each of the four total concentrations.

After the straw had been allowed to dry in a protected place, it was placed in the sun and then weighed. The weighings were repeated on another day in order to check their accuracy. The grain, which had been removed from the panicles, was treated in a similar way.

Table II shows the yield data for the two plants of each culture in Set 1. In this table are given the culture numbers, the air-dry weights of straw, the air-dry weights of grain, the number of bearing culms, the average length of culms, and the average length of panicles. Table III gives the yield data for the two plants of each culture in Set 2. The arrangement is similar to that of Table II, but in Table III the average lengths of leaves and the average widths of leaves are given in addition to the data shown in Table II.

Table IV shows relative yields of straw for the two sets, with the culture giving highest yield with each total concentration considered as having a value of 100. The first column gives the culture numbers. The four sections of the table refer to the T0.5 T1, T2, and T3 groups, respectively. In each section are shown the relative yields for Set 1, the relative yields for Set 2, the average of the relative yields of the two sets, and the average on the basis of the highest average considered as 100. Table V is similar in arrangement to Table IV, but presents data for grain yields.

DISCUSSION OF RESULTS

The results of the experiments here reported will be briefly discussed in the pages which follow. On account of the large mass of data collected and its complexity, only a very general interpretation will be attempted, and only straw and grain yields will be considered.

RELATION OF STRAW AND GRAIN YIELDS TO PROPORTIONS OF SALTS

Proportion of $(NH_4)_2SO_4$

Straw yields.—The triangular diagrams of Figure 2 plotted from the data of Table IV, assist us in making a study of the relation between the yields of straw and the proportions of the fertilizer salts. Inspection of diagram T0.5 (for the cultures having an osmotic value of 0.5 atm.) shows that high straw yields were obtained with culture R1C3 and culture R1C4, whose soil contained the highest and next highest proportions of $(NH_4)_2SO_4$ in the salt mixtures added. Low straw yields in this group were obtained with cultures R1C1 and R2C1, both of which had salt mixtures in which only one sixth of the total osmotic value was due to $(NH_4)_2SO_4$. It appears that with the total concentration of 0.5 atm., high straw yields were obtained with highest proportions of $(NH_4)_2SO_4$, and low straw yields, with lowest proportions of this salt.

Examination of diagram T1 of Figure 2 (for cultures having a total osmotic value of 1 atm.) shows that high yields were obtained with cultures R1C4 and R2C3; these cultures were characterized by salt proportions containing the highest and next to the highest proportions of $(NH_4)_2SO_4$. Low yields were obtained with cultures R1C1 and R2C1, the salt mixtures of which contained the lowest proportion of $(NH_4)_2SO_4$. The distribution of high and low yields in diagram T2 (for cultures having a total osmotic concentration of 2 atm.) is very similar to that of diagrams T1 and T0.5. High yields were obtained with cultures R1C4 and R2C3, and low yields with cultures R1C1 and R2C1. As in the other groups of cultures, the high straw yields were correlated with the highest proportions of $(NH_4)_2SO_4$, and the low yields with the lowest proportion of this salt. Diagram T3 shows that high yields were obtained with cultures R2C2 and R2C3, and low yields with cultures R1C1 and R3C1. It may be concluded that with the three salt fertilizer mixture employed in the present experiment, high straw yields were correlated with the highest proportions of $(NH_4)_2SO_4$, and low yields with the lowest proportions of this salt. This relationship is indicated for total concentrations ranging from 0.5 atm. to 3 atm. It is to be expected that with lower total concentrations than 0.5 atm., high straw yields would also have been obtained with salt mixtures containing the highest proportions of the ammonium salt. Whether or not this relationship would have held with salt mixtures corresponding to higher values than 3 atm. can not, of course, be inferred from the present tests.

Grain yields.—The diagrams of Figure 3, plotted from the data of Table V, bring out relations between grain yields and the proportions of the three fertilizer

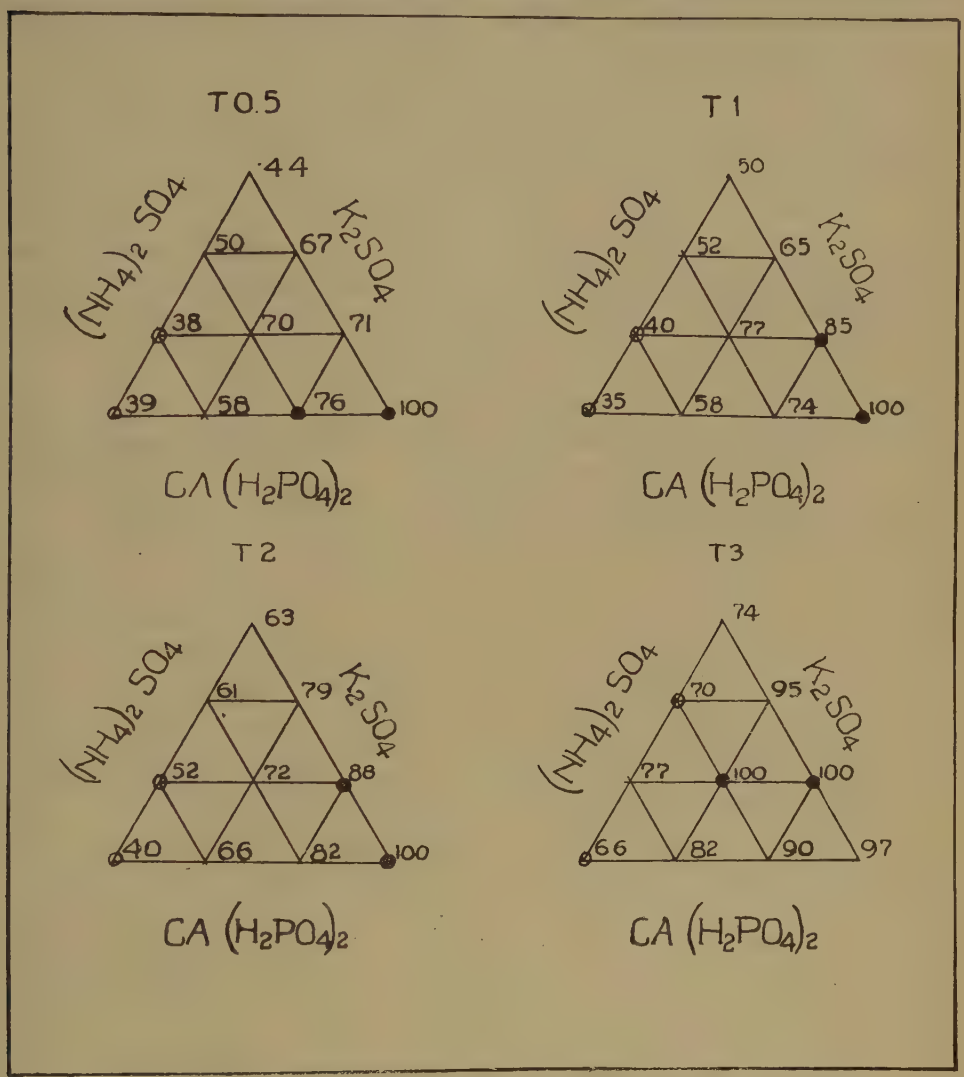

Fig. 2. Diagrams showing relative yields of rice straw. High yields indicated by dots; low, by circles. (Data from Table IV.)

salts. The conclusions for grain yields resemble in a general way those for straw yields, for the high yields of grain were in general correlated with highest proportions of $(NH_4)_2SO_4$, and low yields were correlated with lowest proportions of $(NH_4)_2SO_4$. The correlation is, however, not so clear for grain as it is for straw.

Diagrams T0.5 and T1 are identical in the distribution of high and low grain yields. Since in each diagram high yields are indicated for cultures R1C4 and R1C3, and low yields for cultures R1C1 and R2C1, in these two total concentrations high yields were definitely correlated with high proportions of $(NH_4)_2SO_4$, and low yields with low proportions of this salt. Diagram T2 (for cultures having a total osmotic concentration of 2 atm.) shows that in the T2 group high yields

were obtained with cultures R1C4 and R3C2. The first of these cultures is characterized by the highest concentration of $(NH_4)_2SO_4$, and the second by a comparatively low concentration of this salt. Low yields are indicated for cultures

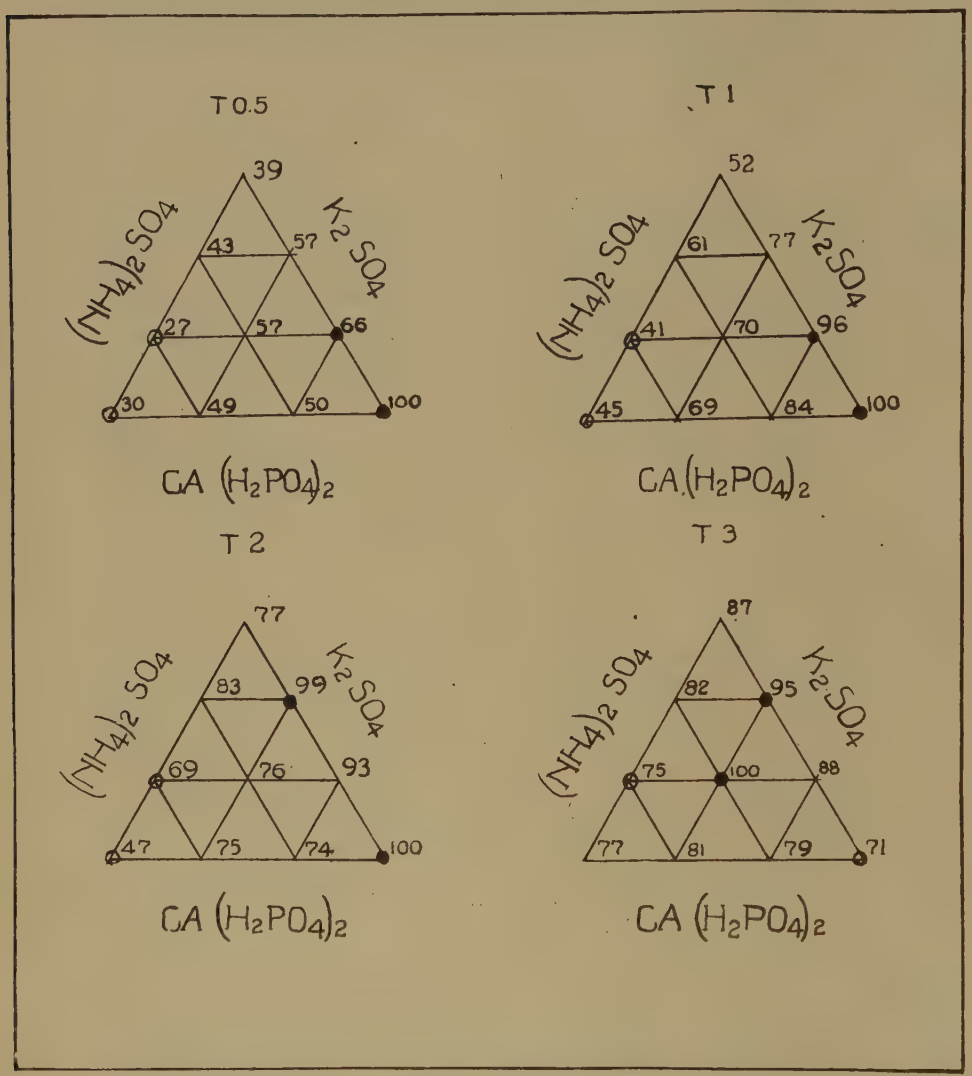

Fig. 3. Diagrams showing relative yields of rice grain. High yields indicated by dots; low, by circles. (Data from Table V.)

R1C1 and R2C1, both of which have the lowest proportion of $(NH_4)_2SO_4$. With a total concentration of 2 atm., low yields were therefore correlated with low proportions of $(NH_4)_2SO_4$ but high yields could not be definitely correlated with the highest proportions of $(NH_4)_2SO_4$. Diagram T3 (for cultures having a total osmotic value of 3 atm.) indicates little correlation between grain yields and proportions of $(NH_4)_2SO_4$; low yields were obtained with one culture (R2C1) having only one sixth of its osmotic value due to $(NH_4)_2SO_4$, and with another culture (R1C4) having four sixths due to $(NH_4)_2SO_4$. Low yields were evidently not related in this test to low proportion of $(NH_4)_2SO_4$, nor were they related to high

proportions of $(NH_4)_2SO_4$. High yields in this diagram are indicated for cultures R2C2 and R3C2, both of which had two sixths of the total concentration of their salt mixture due to $(NH_4)_2SO_4$. No definite correlation between $(NH_4)_2SO_4$ content and grain yield appears to exist for these cultures having a total osmotic value of 3 atm.

In general, it may be concluded that with total concentrations of 0.5, 1, 2 atm., grain yields were correlated in a direct way with the $(NH_4)_2SO_4$ proportion of the fertilizer mixture, higher proportions of $(NH_4)_2SO_4$ giving increased grain yields.

Proportion of $Ca(H_2PO_4)_2$

Straw yields.—Figure 2 should indicate whether a relationship exists between the yields of straw and the proportions of $Ca(H_2PO_4)_2$. It will be observed that in T0.5 high yields were obtained with the lowest proportions of the $Ca(H_2PO_4)_2$, and low yields were obtained with one culture having the lowest proportion of $Ca(H_2PO_4)_2$ and with another culture having next to the lowest proportion of this salt. Since both highest and lowest yields were obtained with low proportions of $Ca(H_2PO_4)_2$, there appears to be no relation between the proportions of $Ca(H_2PO_4)_2$ and the yield of straw, at least with a total concentration of 0.5 atm. A similar statement may be made regarding the distribution of the highest and the lowest yields of straw with reference to concentrations of 1 and 2 atm. The diagram T3 shows that with a total concentration of 3 atm., high yields were obtained with medium proportions of $Ca(H_2PO_4)_2$ (two sixths of the total osmotic value). Low yields were obtained with one culture having the lowest proportion of $Ca(H_2PO_4)_2$ and with another culture having the next to the highest proportion of this salt. It appears, therefore, that with the total concentration of 3 atm. the yield of straw was not correlated with the proportion of $Ca(H_2PO_4)_2$. From these results it may be concluded that straw yields were not definitely correlated with proportions of $Ca(H_2PO_4)_2$. We may, at least, say that increased proportions of $Ca(H_2PO_4)_2$ were not accompanied by increased yields of rice straw.

Grain yields.—The diagrams T0.5 and T1 show that both highest and lowest grain yields were obtained with low proportions of $Ca(H_2PO_4)_2$. The diagram T2 shows that high yields were obtained with both low and high proportions of $Ca(H_2PO_4)_2$, while low yields were obtained only with low proportions of $Ca(H_2PO_4)_2$. The diagram T3 shows, also, that low yields were obtained with low proportions of $Ca(H_2PO_4)_2$, but that high yields were obtained with medium proportions of $Ca(H_2PO_4)_2$. From all four diagrams it is impossible to draw any general conclusion regarding the relationship between grain yields and the proportion of $Ca(H_2PO_4)_2$, except that an increased proportion of $Ca(H_2PO_4)_2$ was not definitely correlated with increased grain yields.

Proportion of K_2SO_4

Straw yields.—The diagrams of Figure 2 indicate that the yield of rice straw was not definitely correlated with the proportions of K_2SO_4 in the fertilizer mixture. They suggest, perhaps, an inverse proportionality between the K_2SO_4 content of the fertilizer mixture and the straw yield; but this inverse relationship is not very definite. The diagram T0.5 shows that high yields were obtained with low and medium proportions of K_2SO_4, and that low yields were obtained with the medium and the highest proportions of K_2SO_4. The diagram T1 and the diagram T2 show that high yields were obtained with lowest proportions of K_2SO_4, and that

low yields were obtained with highest and next to highest proportions of this salt. Thus with total osmotic concentration of 0.5, 1, and 2 atm. an inverse proportionality between the K_2SO_4 content and the yield of rice straw is indicated; it is at least safe to say that increased proportions of K_2SO_4 did not bring about increased yields of straw. There was apparently no clear correlation between K_2SO_4 content and yield of straw for the cultures plotted on T3.

Grain yield.—As in the case of straw yields, there is a suggestion that increased proportions of K_2SO_4 were accompanied by decreased yields of grain; this appears to be particularly true of the cultures having total osmotic concentrations of 0.5, 1, and 2 atm. Although it does not appear advisable to put very strong emphasis upon this suggested inverse proportionality, it is, at least, safe to conclude that increased proportions of K_2SO_4 did not result in increased grain yields. No relation between grain yields and proportions of K_2SO_4 are evident for the cultures having a total osmotic value of 3 atm.

The only general conclusion that may be drawn regarding correlations between grain yields and proportions of fertilizer salts under the conditions of the present experiment appears to be that increased proportions of $(NH_4)_2SO_4$ resulted in increased grain yields for salt mixtures having total osmotic values of 0.5, 1, and 2 atm., and that increased grain yields did not accompany increased proportions of K_2SO_4 and did not accompany increased proportions of $Ca(H_2PO_4)_2$. The results of the present study confirm the conclusions reached in a previous study regarding the importance of $(NH_4)_2SO_4$ under the general experimental conditions here employed (1), and show that even with much higher total concentrations than that employed in the earlier study, $(NH_4)_2SO_4$ is of greater importance than is either $Ca(H_2PO_4)_2$ or K_2SO_4.

RELATION OF STRAW YIELDS TO THE TOTAL CONCENTRATION OF THE FERTILIZER MIXTURE

The data of straw yields of Tables II and III have been brought together in Table VI in such a way as to show the relative yields of straw with each total concentration when the yields for the T0.5 cultures are considered as having a relative value of 100. This table enables one to see the comparative efficiency of the four total concentrations for each set of fertilizer proportions.

Table VI shows the relative yields of dry straw for the two sets with each of the cultures of T0.5 considered as having a relative value of 100. The first column gives the culture numbers. In each of the four sections of the table (T0.5, T1, T2, and T3), are given the relative yields for Set 1, the relative yields for Set 2, and the average for the two sets.

With the salt proportions of culture R1C1, when the relative average yield for 0.5 atm. is considered as 100, the corresponding relative average yield with a total osmotic value of 1 atm. is 135; of 2 atm., 194; and of 3 atm., 321. With this set of salt proportions the yield of straw increases with each increase in total concentration, but the increase in yield of straw is not proportional to the increase in quantity of fertilizer. The T1 culture, having double the quantity of fertilizer used with the T0.5 culture, did not give double yield of straw, but gave a yield of 135, as compared with a yield of 100 for the T0.5 culture. The culture of T2, which had four times the amount of fertilizer supplied to T0.5, gave a yield of

only 194. The culture of T3, having six times the amount of fertilizer, gave a yield of only 321. From this table we can easily see the comparative increase in yield produced by the increase in concentration, and select the total concentration that gave highest yield with each set of salt proportions. With the salt proportions of cultures R1C1, R1C2, R1C3, R2C1, R2C2, R2C3, R3C1, R3C2, and R4C1, highest straw yields were obtained when a total concentration of 3 atm. was used. Thus it is to be noted that with all sets of proportions except those of culture R1C4, best growth, as shown by straw yields, was obtained with a total concentration of 3 atm. With culture R1C4 best growth was obtained with a total concentration of 2 atm.

At the bottom of Table VI are given mean relative values for all of the sets of salt proportions for each of the four total concentrations. It will be seen that this mean value is 100 with a total concentration of 0.5 atm., 164 with a total concentration of 1 atm., 228 with a total concentration of 2 atm., and 277 with a total concentration of 3 atm. Considering all of the salt proportions tested, it is evident that increased concentrations resulted in corresponding increased yields of straw; but that the increases in yield were not strictly proportional to the increases in total concentration. This is demonstrated by the fact that double the concentration produced about 1½ times the yield; four times the concentration produced only about 2¼ times the yield; six times the concentration produced only 2¾ times the yield. It is seen that the rate of increase in yield diminished in comparison with the rate of increase in concentration of the salts applied.

RELATION OF GRAIN YIELDS TO THE TOTAL CONCENTRATION OF THE FERTILIZER MIXTURE

The data of grain yields of Tables II and III are given in Table VII in such a way as to show the relative yields of grain with each total concentration when the yields for the T0.5 cultures are considered as having a relative value of 100. In Table VII grain yields are presented in a form similar to that used for straw yield in Table VI. Table VII shows the comparative efficiency of the four total concentrations for each set of fertilizer proportions. From this table may be seen the comparative change in yield of grain produced by increase in total concentration; and the total concentration giving highest yields may be selected for each set of salt proportions. Highest yields were obtained with a total concentration of 3 atm. for the following sets of salt proportions: R1C1, R1C2, R1C3, R2C1, R2C2, R3C1, and R4C1. Highest yields were obtained with a total concentration of 2 atm. for the following sets of salt proportions: R1C4, R2C3, R3C1, R3C2. Highest yields were never obtained with a total concentration of 1 atm. or 0.5 atm. There is an indication in these results that with cultures having salt proportions characterized by high relative proportions of $(NH_4)_2SO_4$ a total concentration of 3 atm. was too high to give best grain yields. This suggests an injurious effect from very high actual amounts of $(NH_4)_2SO_4$. It was observed that nearly all of the cultures having a total concentration of 3 atm. had relatively soft and weak leaves, which drooped in a way that is not normal for best rice. This apparently was connected with very high proportions of $(NH_4)_2SO_4$. "Lodging" of rice is often reported to be brought about by heavy application of fertilizers. The lower grain yield in these cultures may have been connected with an

excessive amount of $(NH_4)_2SO_4$. Russell (3) states that a very large amount of nitrogenous fertilizers causes the proportion of grain to decrease, cereal crops producing a very high proportion of straw if the nitrogen supply is excessive. This is indicated in the present experiment, since it was seen from Table VI that with all sets of salt proportions except that of culture R1C4, highest yields of straw were obtained with a total concentration of 3 atm., while highest yields of grain were obtained with four of the sets of salt proportions with a total concentration of 2 atm. It appears, therefore, that for most of the sets of salt proportions a total concentration of 3 atm. was best for the production of straw, while this concentration is too high for the highest production of grain with a number of the sets of salt proportions.

At the bottom of Table VII are given mean relative values for all of the sets of salt proportions for each total concentration. The mean value is 100 with a total concentration of 0.5 atm., 171 with a total concentration of 1 atm., 229 with a total concentration of 2 atm., 248 with a total concentration of 3 atm. Considering all sets of salt proportions, the highest mean value is thus indicated for a total concentration of 3 atm. Increases in yield of grain accompanied increases in total concentration, but these increases in yield were not strictly proportional to the increases in total concentration, and the relation of grain yields to concentration again indicates diminishing returns. Since grain is the commercial product of the rice plant, the effect of fertilizer on the yield of grain must be considered as more important than its effect upon the yield of straw; and in practical agriculture the amount and kind of fertilizer must be governed by consideration of greatest profit from grain yield.

RELATION OF THE INCREMENT IN YIELD TO THE INCREMENT CONCENTRATION

The straw and grain yields are summarized in Table VIII in such a way as to show the relative increment in yield per unit increment in concentration of the added fertilizer mixtures. In the first column of this table is given the concentration in atmospheres of the salt mixture added to the cultures. The first concentration added is 0.0 (for the control); the other concentrations are of course 0.5, 1.0, 2.0 and 3.0 atm. The second column gives the increment in concentration; the third gives the relative yield of straw (these values are taken from columns 4, 7, 10 and 13 of Table VI). The fourth column of Table VIII gives the increment in yield, The fifth column gives the ratio obtained by dividing the increment in yield by the increment in concentration. The figures in this column represent relative increments in yield of straw per unit increment in total concentration. The sixth, seventh, and eighth columns give corresponding data for grain yield. An examination of the values in the fifth column shows that the relative increment in straw yield per unit increment in concentration decreases as the concentration increases. For example, the first increment in concentration (from 0 to 0.5 atm.) produced an increment of 140 per unit increment in concentration. The second increment in concentration produced a corresponding increment of 128 in the ratio; the third of 64, and the fourth of 49. These values illustrate again very well the law of diminishing returns, as affecting the relation of straw yield to increase in total amount of fertilizer.

The ratio values in the last column of Table VIII, which are similar to those in the fifth column, show that the increment in grain yield per unit increment in

concentration decreased from 156 to 19 with an increase in concentration from 0 to 3.0 atm. The law of diminishing returns is again shown for grain yields, as it was for straw yields. The first increment in fertilizer produced a relatively high increment in grain yield per unit change in concentration. Successive increments produced lower and lower values of the ratio. It is seen, therefore, that while the absolute values for straw and for grain yields increased with an increase in the total concentration of the fertilizer, the relative increment in yield per unit increment in concentration decreased with successive additions of fertilizer.

An increase in the amount of fertilizer applied did not yield a proportional increase in product; the increase in amount of fertilizer increased the product, but did not increase the product in proportion as the fertilizer application increased. Applications of smaller amounts of fertilizer than any used in the present tests should be studied with the aim of determining the range of concentrations that would give increased yields per unit of fertilizer and of determining the maximum concentration above which increased applications of fertilizer would result in decreased yields per unit of fertilizer. It will be noted that for straw yields, at least, higher total concentrations should also be studied in order to determine the optimum total concentration; i.e., the concentration giving greatest actual yields (regardless of the yield per unit of concentration). The highest actual yield in the present experiments was obtained with the highest total concentration here tested. But it is to be expected that with still higher concentrations, first a highest possible actual yield and finally a decreased actual yield would be obtained. This has been found to be true with work in solution cultures (10). But it seems probable that even the total concentrations used in the present study are much higher than would prove profitable in practical agriculture. In agricultural practice the aim, of course, is to use an amount of fertilizer that will give greatest profit, involving, as an extraneous condition, relative market price of fertilizer and product. On account of the law of diminishing returns, the amount of fertilizer giving greatest profit will be less than the amount giving greatest possible actual yield. The foregoing statements are merely suggestions brought out by the nature of the data obtained in the present experiments. Field tests of course must be made in order to determine the most profitable amount of fertilizer to be applied. It may very well be true that with the present high cost of fertilizer materials in the Philippine Islands it is not profitable to use them.

For general discussions regarding the influence of the concentration of the nutrient medium, the reader is referred to papers by Livingston (8), Breazeale (9) and Trelease (10).

SUMMARY OF CONCLUSIONS

The amount and kind of growth made by rice plants growing in water-saturated soil was determined by (1) the relative proportions of added fertilizer salts, and (2) the total concentration of added fertilizer salts. In the experiments reported in this paper ten different sets of proportions of primary calcium phosphate, ammonium sulphate, and potassium sulphate were employed. These ten sets included all mixtures of the three salts in which each makes up from one to four sixths of the total osmotic value of the mixture. Each set of salt proportions was tested in four total concentrations.

With the three-salt mixtures employed in the study here reported, highest straw and highest grain yields were in general definitely correlated with salt mix-

tures containing highest proportions of ammonium sulphate [$(NH_4)_2SO_4$],) and lowest with those containing lowest proportions of this salt. This correlation was very marked for straw yields with salt-mixtures corresponding to 0.5, 1.0, 2.0, and 3.0 atm., and for grain yields with salt-mixtures corresponding to 0.5, 1.0, and 2.0 atm.

Neither straw nor grain yields could be definitely related to the proportions of primary calcium phosphate [$Ca(H_2PO_4)_2$], and they could not be related to the proportions of potassium sulphate [K_2SO_4].

The yields of grain and of straw were roughly proportional to the actual concentrations of ammonium sulphate [$(NH_4)_2SO_4$] of the fertilizer mixtures for a range in these concentrations from 0.083 atm. to about 1.33 atm.

Neither the yields of grain nor those of straw showed any definite relation to the actual concentrations of either primary calcium phosphate [$Ca(H_2PO_4)_2$, or potassium sulphate [K_2SO_4].

With nine out of the ten sets of salt proportions employed in the present study higher yields of straw were obtained with a total concentration of 3 atm. than with concentrations of 0.0, 0.5, 1.0, and 2.0 atm. With one set of salt proportions higher straw yields were obtained with a concentration of 2 atm. than with any one of the other three concentrations.

With six out of the ten sets of salt proportions higher yields of grain were secured with a concentration of 3 atm. than with concentrations of 0.5, 1.0, or 2.0 atm. With four sets higher grain yields were secured with a concentration of 2.0 atm.

Considering the average straw yields obtained with all sets of fertilizer proportions tested, the first increment in concentration produced a relative increment of 140 per unit increment in concentration; the second, a relative increment of 128; the third a relative increment of 54; and the fourth, a relative increment of 49.

Considering the average grain yields obtained with all sets of fertilizer proportions tested, the first increment in concentration produced a relative increment of 156 per unit increment in concentration; the second, relative increment of 142; the third, a relative increment of 58; and the fourth, a relative increment of 19.

Increased amounts of fertilizer increased the products (straw and grain) until the amount of fertilizer corresponded to from 2.0 to 3.0 atm. But the increase in the amount of fertilizer applied did not yield a proportional increase in the products.

It is suggested that additions of smaller amounts of fertilizer should be studied, in order to determine the concentration of fertilizer above which increased concentrations would result in decreased yields per units of fertilizer.

TABLE I.—*Amount of salt added to soil in culture vessel having a capacity of 19 liters.*

Culture number.	$Ca(H_2PO_4)_2$.	$m/2(NH_4)_2SO_4$.	$m/2K_2SO_4$.
	gm.	*cc.*	*cc.*
T.5 R1C1	6.3	50	200
T.5 R1C2	6.3	100	150
T.5 R1C3	6.3	150	100
T.5 R1C4	6.3	200	50
T.5 R2C1	12.6	50	150
T.5 R2C2	12.6	100	100
T.5 R2C3	12.6	150	50
T.5 R3C1	18.9	50	100
T.5 R3C2	18.9	100	50
T.5 R4C1	25.2	50	50
T 1 R1C1	12.6	100	400
T 1 R1C2	12.6	200	300
T 1 R1C3	12.6	300	200
T 1 R1C4	12.6	400	100
T 1 R2C1	25.2	100	300
T 1 R2C2	25.2	200	200
T 1 R2C3	25.2	300	100
T 1 R3C1	37.8	100	200
T 1 R3C2	37.8	200	100
T 1 R4C1	50.5	100	100
T 2 R1C1	25.2	200	800
T 2 R1C2	25.2	400	600
T 2 R1C3	25.2	600	400
T 2 R1C4	25.2	800	200
T 2 R2C1	50.4	200	600
T 2 R2C2	50.4	400	400
T 2 R2C3	50.4	600	200
T 2 R3C1	75.7	200	400
T 2 R3C2	75.7	400	200
T 2 R4C1	100.9	200	200
T 3 R1C1	37.8	300	1200
T 3 R1C2	37.8	600	900
T 3 R1C3	37.8	900	600
T 3 R1C4	37.8	1200	300
T 3 R2C1	75.6	300	900
T 3 R2C2	75.6	600	600
T 3 R2C3	75.6	900	300
T 3 R3C1	113.5	300	600
T 3 R3C2	113.5	600	300
T 3 R4C1	151.3	300	300

TABLE II.—*Yield data for rice. T1 and T0.5 harvested on November 8, 1919; T2 and T3 harvested on November 15, 1919. For two plants. Set 1.*

Culture number.	Air-dry wt. of straw.	Air-dry wt. of grain.	Number of bearing culms.	Av. length of culms.	Av. length of panicles.
	gm.	*gm.*		*cm.*	*cm.*
T.5 R1C1	70	62	19	99.9	24.1
T.5 R1C2	95	95	28	104.2	25.1
T.5 R1C3	128	[a]80	35	102.3	23.6
T.5 R1C4	149	143	38	112.3	26.5
T.5 R2C1	65	51	18	97.9	22.0
T.5 R2C2	113	111	30	104.3	24.7
T.5 R2C3	115	124	37	103.6	25.0
T.5 R3C1	78	72	22	105.5	23.0
T.5 R3C2	107	106	34	99.6	23.5
T.5 R4C1	69	72	22	99.0	24.5
T1 R1C1	102	113	31	104.4	24.4
T1 R1C2	144	149	44	106.0	26.0
T1 R1C3	184	204	60	109.6	24.9
T1 R1C4	231	253	76	109.8	24.9
T1 R2C1	99	104	34	102.7	23.2
T1 R2C2	176	[a]119	49	107.0	24.7
T1 R2C3	188	202	68	108.2	24.9
T1 R3C1	117	118	35	104.2	24.3
T1 R3C2	156	158	45	106.0	24.8
T1 R4C1	119	115	33	105.7	24.5
T2 R1C1	157	165	44	107.6	25.0
T2 R1C2	218	205	63	111.2	26.0
T2 R1C3	282	225	73	113.3	25.0
T2 R1C4	310	246	75	120.7	24.5
T2 R2C1	169	158	50	107.9	25.0
T2 R2C2	200	163	54	114.7	24.6
T2 R2C3	237	213	72	114.7	24.6
T2 R3C1	164	165	49	111.5	24.2
T2 R3C2	226	241	79	108.3	24.7
T2 R4C1	149	172	47	108.7	25.1
T3 R1C1	201	173	66	104.9	23.0
T3 R1C2	240	212	70	108.2	26.4
T3 R1C3	283	225	76	116.8	24.7
T3 R1C4	272	178	72	111.1	25.1
T3 R2C1	214	138	55	115.7	23.1
T3 R2C2	283	233	81	115.2	26.6
T3 R2C3	270	173	72	115.0	24.0
T3 R3C1	167	162	54	109.8	24.0
T3 R3C2	227	204	71	108.7	24.7
T3 R4C1	194	199	68	102.5	25.0
Control 1	29	26	11	90.3	22.7
Control 2	28	21	10	86.8	22.4
Control 3	23	20	9	87.4	23.2
Av. Control	27	22	10	88.1	22.8

[a] Attacked by rats.

TABLE III.—*Yield data for rice. T1 and T0.5 harvested on December 19, 1919. T2 and T3 harvested on December 26, 1919. For two plants. Set 2.*

Culture number.	Air-dry wt. of straw.	Air-dry wt. of grain.	Number of bearing culms.	Av. length of culms.	Av. length of panicle.	Av. length of leaves.	Av. width of leaves.
	gm.	*gm.*		*cm.*	*cm.*	*cm.*	*cm.*
T.5 R1C1	33	28	16	84.5	19.1	42.6	1.36
T.5 R1C2	54	46	18	89.0	20.9	48.0	1.48
T.5 R1C3	68	68	22	97.2	22.3	49.0	1.37
T.5 R1C4	105	150	45	100.2	22.3	45.3	1.40
T.5 R2C1	34	27	13	81.2	19.9	38.1	1.18
T.5 R2C2	66	53	20	95.2	21.1	45.8	1.28
T.5 R2C3	68	68	26	93.9	22.4	43.6	1.36
T.5 R3C1	50	54	18	89.5	20.5	46.3	1.40
T.5 R3C2	65	60	26	93.2	21.0	49.4	1.44
T.5 R4C1	43	40	18	81.7	18.9	39.5	1.24
T1 R1C1	41	47	20	96.6	21.5	49.7	1.42
T1 R1C2	90	93	39	96.3	24.8	48.5	1.44
T1 R1C3[a]	112	101	40	93.1	20.7	39.2	1.50
T1 R1C4	167	114	53	107.8	24.2	46.6	1.50
T1 R2C1	62	49	18	99.4	21.6	47.5	1.39
T1 R2C2	128	110	36	102.3	23.7	45.0	1.30
T1 R2C3	148	131	43	103 0	22.8	44.3	1.36
T1 R3C1	88	87	27	99.5	22.5	48.4	1.28
T1 R3C2	102	106	35	102.6	23.0	46.9	1.43
T1 R4C1	81	69	28	90.2	20.2	43.5	1.29
T2 R1C1[a]	54	41	15	100.9	25.7	49.6	1.48
T2 R1C2[a]	117	101	33	106.1	24.2	45.5	1.59
T2 R1C3[a]	136	86	47	99.4	22.4	47.4	1.43
T2 R1C4	190	150	53	105.5	23.6	42.6	1.45
T2 R2C1	94	111	35	108.0	24.0	46.5	1.31
T2 R2C2	150	129	40	99.8	22.9	43.1	1.53
T2 R2C3	189	150	51	100.0	24.0	49.3	1.42
T2 R3C1	132	148	48	97.1	22.4	46.9	1.40
T2 R3C2	161	151	53	99.6	25.4	48.6	1.48
T2 R4C1	147	126	39	100.0	24.0	52.1	1.51
T3 R1C1[a]	117	120	45	100.4	24.0	46.3	1.46
T3 R1C2[a]	138	106	41	103.4	22.6	49.9	1.51
T3 R1C3[a]	155	89	35	101.9	24.3	46.2	1.54
T3 R1C4[a]	190	98	56	97.3	20.9	38.1	1.55
T3 R2C1	148	135	40	108.7	25.2	50.0	1.42
T3 R2C2	194	150	61	96.7	23.1	49.4	1.43
T3 R2C3	204	154	64	96.7	24.3	52.1	1.45
T3 R3C1	160	150	51	105.8	23.2	45.2	1.45
T3 R3C2	221	153	46	100.4	22.3	44.8	1.46
T3 R4C1	157	132	45	99.9	25.7	47.5	1.46
Control 1	18	7	5	82.2	21.2	33.6	1.23
Control 2	19	13	6	80.2	19.7	41.3	1.40
Control 3	20	15	6	83.3	20.8	35.6	1.41
Av. Control	19	12	6	81.9	20.6	36.8	1.35

[a]Attacked by insects.

TABLE IV.—*Relative yields of dry straw; culture giving highest yield considered as 100.*

Culture Number.	T 0.5				T 1				T 2				T 3			
	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.
R1C1	47	31	39	39	44	25	35	35	51	28	40	40	71	53	62	66
R1C2	64	51	58	58	62	54	58	58	70	62	66	66	92	62	77	82
R1C3	86	65	76	76	80	67[a]	74	74	91	72	82	82	100	70	85	90
R1C4	100 (149)	100 (105)	100	100	100 (231)	100 (167)	100	100	100 (310)	100 (190)	100	100	(283) 96	86	91	97
R2C1	44	32	38	38	43	37	40	40	55	49	52	52	76	67	72	77
R2C2	76	63	70	70	76	77	77	77	65	79	72	72	100	88	94	100
R2C3	77	65	71	71	81	89	85	85	76	99	88	88	95	92	94	100
R3C1	52	48	50	50	51	53	52	52	53	69	61	61	59	72	66	70
R3C2	72	62	67	67	68	61	65	65	72	85	79	79	80	100	90	95
R4C1	46	41	44	44	52	48	50	50	48	77	63	63	(221) 69	71	70	74

[a] Attacked by insects.

TABLE V.—*Relative yields of dry grain; culture giving highest yield considered as 100.*

Culture number.	T 0.5				T 1				T 2				T 3			
	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.	Relative yield; Set 1.	Relative yield; Set 2.	Average of relative yields for 2 sets.	Average on basis of highest as 100.
R1C1	43	17	30	30	45	36	42	45	67	27[a]	47	47	74	78a	76	77
R1C2	66	31	49	49	59	71	65	69	83	67[a]	75	75	91	69a	80	81
R1C3	55	45	50	50	81	77[a]	79	84	91	57[a]	74	74	97	58a	78	79
R1C4	100 (143)	100 (150)	100	100	100 (253)	87	94	100	100 (246)	99	100	100	76	64a	70	71
R2C1	36	18	27	27	41	37	39	41	64	74	69	69	59	88	74	75
R2C2	78	35	57	57	47	84	66	70	66	85	76	76	100 (233)	97	99	100
R2C3	87	45	66	66	80	100 (131)	90	96	87	99	93	93	74	100 (154)	87	88
R3C1	50	36	43	43	47	66	57	61	67	98	83	83	65	97	81	82
R3C2	74	40	57	57	62	81	72	77	98	100 (151)	99	99	88	99	94	95
R4C1	50	27	39	39	45	53	49	52	70	83	77	77	85	86	86	87

[a] Attacked by insects.

TABLE VI.—*Relative yields of dry straw; cultures of T 0.5 considered as 100.*

Culture number.	T 0.5.			T 1.			T 2.			T 3.		
	Relative yield; Set 1.	Relative yield; Set 2.	Relative average.	Relative yield; Set 1.	Relative yield; Set 2.	Relative average.	Relative yield; Set 1.	Relative yield; Set 2.	Relative average.	Relative yield; Set 1.	Relative yield; Set 2.	Relative average.
R1C1	100 (70)	100 (33)	100	146	124	135	224	164[a]	194	287	355[a]	321
R1C2	100 (95)	100 (54)	100	152	167	160	229	217[a]	223	253	256[a]	255
R1C3	100 (128)	100 (68)	100	144	165[a]	155	220	200[a]	210	221	228[a]	225
R1C4	100 (149)	100 (105)	100	155	159	157	208	181	195	183	181[a]	182
R2C1	100 (65)	100 (34)	100	152	182	167	260	276	268	329	435	382
R2C2	100 (113)	100 (66)	100	156	194	175	177	227	202	250	294	272
R2C3	100 (115)	100 (68)	100	163	218	191	206	278	242	235	300	268
R3C1	100 (78)	100 (50)	100	150	176	163	210	264	237	214	320	267
R3C2	100 (107)	100 (65)	100	150	157	154	211	248	230	212	340	276
R4C1	100 (69)	100 (43)	100	172	188	180	216	342	279	281	365	323
Average	100	100	100	154	173	164	216	240	228	247	307	277

[a]Attacked by insects.

TABLE VII.—*Relative yields of dry grain; cultures of T 0.5 considered as 100.*

Culture number.	T 0.5.			T 1.			T 2.			T 3.		
	Relative yield; Set 1.	Relative yield; Set 2.	Average.	Relative yield: Set 1.	Relative yield; Set 2.	Average.	Relative yield; Set 1.	Relative yield; Set 2.	Average.	Relative yield: Set 1.	Relative yield; Set 2.	Average.
R1C1	100 (62)	100 (28)	**100**	182	168	**175**	266	146[a]	**206**	279	429[a]	**354**
R1C2	100 (95)	100 (46)	**100**	157	202	**180**	216	220[a]	**218**	223	230[a]	**227**
R1C3	100a (80)	100 (68)	**100**	255	149[a]	**202**	281	126[a]	**204**	281	131[a]	**206**
R1C4	100 (143)	100 (150)	**100**	177	76	**127**	172	100[a]	**136**	124	65[a]	**95**
R2C1	100 (51)	100 (27)	**100**	204	181	**193**	310	411	**361**	270	500	**385**
R2C2	100 (111)	100 (53)	**100**	107	208	**158**	147	243	**195**	210	283	**247**
R2C3	100 (124)	100 (68)	**100**	163	193	**178**	172	221	**197**	140	226	**183**
R3C1	100 (72)	100 (54)	**100**	164	161	**163**	229	274	**252**	225	278	**252**
R3C2	100 (106)	100 (60)	**100**	149	177	**163**	227	252	**240**	192	255	**224**
R4C1	100 (72)	100 (40)	**100**	160	173	**167**	239	315	**277**	276	330	**303**
Average	100	100	**100**	172	169	**171**	226	231	**229**	222	273	**248**

[a] Attacked by insects.

TABLE VIII.—*The ratio of increments in yield to increments in concentration; the relative increment in yield per unit increment in concentration. For straw and for grain. Data from Tables II, III, VI, VII.*

Concentration.	Increment in concentration.	Straw.			Grain.		
		Yield (relative).	Increment in yield.	Increment in yield ÷ increment in concentration	Yield (relative).	Increment in yield.	Increment in yield ÷ increment in concentration.
atm.	*atm.*						
0.0	—	30	—	—	22	—	—
0.5	0.5	100	70	140	100	78	156
1.0	0.5	164	64	128	171	71	142
2.0	1.0	228	64	64	229	58	58
3.0	1.0	277	49	49	248	19	19

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COLLEGE AND ALUMNI NOTES

The College of Agriculture was well represented in the Agricultural Congress both through its faculty and its alumni. Professor Elayda, of the department of agronomy, held the most exacting and very important position of secretary of the Congress and chairman of the committee on admissions. Professor Gonzalez, of the department of animal husbandry, was chairman of the committee on agricultural education. Professor Roxas, of the department of chemistry, was a prominent member of the sugar committee. Assistant Professor Mendiola, of the department of agronomy, was head of the committee on miscellaneous matters. Mr. Gaudencio Consunji, B. Agri. '15, served on the committee on locusts and other pests, while Mr. Joaquin Gonzalez, B. Agri. '19, was on the committee on miscellaneous matters.

Relative to the services of Professor Elayda as secretary of the Agricultural Congress the following is from a letter sent to Sr. Don. Mauro Prieto, President of the Fifth Agricultural Congress, by Dean Baker:

The circular letter sent to members of the College of Agriculture faculty in recognition of their efforts to make the Farmer's Congress of this year a greater success than ever and with a greater degree of effective results, is most highly appreciated by us as a kindly and thoughtful courtesy.

It appears to us, however, that whatever of recognition is given members of this staff, is due almost entirely to Professor Inocencio Elayda. No one knows better than we do of the enormous amount of energy and hard work he threw into the project of making this year's Congress a real mile-stone in the development of the Philippines and the Filipino people. Whatever was done by others here was done because Professor Elayda spurred them up to the doing of it. During very many days of the Congress, his work was continuous from early morning to midnight.

Professor Elayda gave himself without reservation to this project at a greater sacrifice than is publicly known. His family was seriously afflicted with illness, and his loyal wife refused to trouble him with this since she understood the great effort he was making for the Congress, with the result that his beloved little son died while he was at the Congress without his being present to do what might have been possible to avert the catastrophe.

The College of Agriculture of the University of the Philippines is highly honored by the opportunity for such service as its faculty could give, although deep sorrow and regret are felt over the great personal sacrifice connected with Professor Elayda's service as Secretary of the Congress.

In the deliberations of the Agricultural Congress, faculty members played a large part. Dr. Roxas addressed the body on the matter of sugar cane improvement and on losses of cane sugar in the processes of manufacture. Dr. Mendiola spoke on seed selection of rice and Professor Gonzalez on certain phases of cattle raising under ranch conditions.

Professor Otto A. Reinking, of the department of plant pathology, returned August 5 from an extended trip through Indo-China, Straits Settlements and Siam. The trip was made in the interests of the College of Agriculture and the United States Department of Agriculture. The purpose of the trip was the study of citrus and its diseases in the regions mentioned.

Professor Reinking left Manila on April 21, and on April 25 he arrived at the Canton Christian College where he inspected the citrus plantation. In company with Professor G. W. Groff of that College, Professor Reinking arrived at Saigon, Indo-China, on May 16.

With the co-operation of Mr. Albert Magen, Director of the Botanic Gardens of Saigon, and Mr. H. Balencie, Director de l'Ecole d'Agriculture de Ben Cat, trips were made to numerous orchards of varied tropical fruits in the vicinity of Saigon and in the Long Mot, Lim Yam, Bencot, and Gei Pay districts. Here collections of diseased material were obtained.

On May 25, Professor Reinking proceeded by motor and boat to Banan, Pnompenh, Kep, and finally Bangkok, collecting and noting conditions along the way. At Bangkok the Ministry of Agriculture was presented with a collection of citrus plants. Professor Reinking reports most cordial treatment by the officials and people of Siam. He reports the country as most ardent in furthering scientific agriculture within its boundaries. He mentions espec-

ially Mr. W. A. Graham, Adviser to the Ministry of Agriculture, Phya Manapokar, Secretary to the Minister of Agriculture, Phra Krasetr, Director of the Bangkok Agricultural Experiment Station,and Dr. Yia Sanitwongse, a wealthy fruit grower north of Bangkok and an enthusiast in furthering scientific endeavor in Siam.

Aboard a Government house-boat, Professor Reinking left Bangkok for Nakorn Chaisri which is up the Tachin river in a notable pummelo region. Here was found an excellent seedless pummelo and some very fine seeded varieties. Professor Reinking collected bud wood and living plants for shipment to Los Baños. These arrived in good condition and are being cultured in our plantations.

Early in July, Professor Reinking traveled southward down the Malay peninsula passing through lower Kedah to Penang, thence to Kuala Lumpur where he spent a day with Dr. F. W. Foxworthy who is Forest Officer of the Federated Malay States. Dr. Foxworthy was formerly in charge of the School of Forestry, University of the Philippines. At Kuala Lumpur, Professor Reinking also met Mr. L. Lewton Brain, Director of the Department of Agriculture, and Mr. A. S. Sharples, mycologist for the Federated Malay States.

On July 11, Professor Reinking arrived in Singapore, where he met Mr. L. K. Burkill and Mr. T. F. Chipp, Director and Assistant Director, respectively, of the Singapore Botanic Gardens. He spent several days collecting there and at Johore. From Singapore he returned to the Islands via Hongkong.

The Cine Makiling Company has been organized by the students and faculty of the College of Agriculture. It will give moving pictures on the College Campus on Friday and Saturday evenings. Shares of stock are being sold at five pesos a share. At a meeting of the stockholders on August 22, matters of policy and permanent organization were decided, and the following officers were elected: Board of Directors: Dean Baker, Professor Cuzner and Dr. Roxas; President, Professor Gonzalez; Vice President, Dr. Espino; Secretary-Treasurer, Mr. Vibar. It is expected that the cine will commence operations during the month of September.

Mr. Mencias, formerly principal of the University High School, has been appointed to a temporary position as assistant professor of English.

A delegation from the Agricultural Congress visited the College on August 28. Due to inclement weather only fifty ventured to leave Manila. A banquet was given for them at the College. Professor Gonzalez acted as toastmaster and speeches were delivered by several delegates and by Dean Baker.

The athetic season opened at the College on July 3 with all teams actually engaging in practice. The baseball team is developing fast and will prove a dangerous team for any opponent to handle. The basketball team opened with an easy victory over the College of Education on August 2. The score was 44 to 5 at the end of the ten minutes of play. The following Saturday, August 28, the College of Engineering came to Los Baños and received a sound beating. The score was 38 to 5. If the basketball team continues to play as it has up to the present, there appears to be no doubt that the College will take the championship.

A long-felt need has been filled by the purchase of two Ford Auto Trucks. Both trucks are of the ton-and-a-half class. It is planned to build a bus body on one and use it for transportation between the College and the railroad station.

Dr. Policoff, professor of surgery of the College of Veterinary Science, left early in September for the United States on the U. S. A. T. *Madawaska* on leave of absence. Dr. Policoff was a new arrival in the Islands and had been here only one month. Mrs. Policoff was taken ill and was obliged to return to the States for medical attention. Dr. Policoff expects to return to the Islands shortly.

Dr. James B. Ashcraft has been appointed professor of surgery in the College of Veterinary Science and Medicine. Professor Ashcraft graduated from the Connecticut Agricultural College in 1910 where he had specialized in Animal Husbandry. He was for four years manager of a large dairy farm in Richmond, Vir-

ginia, and for two years he managed a similar farm in Owatonna, Minnesota. He graduated from Ohio State University with the degree of Doctor of Veterinary Medicine in 1920.

Leoncio Custodio, a second year preparatory student, died Friday, September 3rd, at his home in Cavinti, Laguna. He left the College suffering from an infection in his ear and was advised to go to the hospital. Instead, he went home where he died suddenly while sitting in a chair.

Mr. Eduardo Quisumbing, instructor of plant physiology, a government pensionado, left for the United States on July 16. He will devote his time to the study of botany in the University of Chicago and in other leading Universities.

Mr. Cecilio Alincastre, instructor of chemistry, government pensionado, left for the United States on July 16. Mr. Alincastre will specialize in sugar engineering. He will study in the Universities of Illinois, Louisiana, at Cornell University, and at Massachusetts Institute of Technology.

Mr. Gerardo Ocfemia, instructor of plant pathology, a government pensionado, left for the United States on board U. S. A. T. *Madawaska*, September 4, 1920. Mr. Ocfemia will study at the University of Wisconsin and will specialize in plant pathology.

A shipment of sixty-seven pure bred Hereford cattle was received recently at the College. These cattle are part of the shipment received by the Bureau of Non-Christian Tribes. They will remain at the College for quarantine for a short time and will then be shipped to various places in the Islands. They are being cared for by the animal husbandry department.

The second At Home Day of the College of Agriculture was held on Saturday, September 4, at nine o'clock in the morning in the auditorium. The following program was rendered:

1. Music by the College Orchestra.
2. Piano Selection by Mr. Jaojoco.
3. Speech, "Our social standing" by Mr. Peña.
4. Quartette by Messrs. Jamias, Felipe, Bajamundi, and Bacol.
5. Talk, "Experiences in the States" by Mr. Mondoñedo.
6. Music by the College Orchestra.

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The College of Agriculture is in its twelfth year, with a student body of 527. It occupies a tract of about three hundred and sixty hectares on which every important crop in the Philippines is under cultivation. It has a large series of varieties of leading crops and very numerous introduced plants under tests and observation. The number of distinct cultures, not including series of fertilizer experiments, is more than two thousand. The College has fifteen concrete buildings and several of mixed materials.

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